§37. Study on MHD Wall Shear Turbulent Flow with Heat Transfer

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1. Objectives

Turbulent simulation is possible to apply to the large Reynolds number via developing large scale computer, and the computation is close to the realized engineering facilities. In the high Reynolds number computation, the large scale structures must be understood by not local structures but that of whole region in computational domain. Therefore, we need large memory for not only main computer but also visualization computer. On the other hand, the large scale computation under a magnetic field have been carried out by Satake et al. (2006), the previous study show the relationship of large-scale trurbulent structures and a magnetic field. In this study, the objective is to calculate the large scale turbulent structures with heat transfer under a magnetic field. In this study, the fully developed turbulent flow with heat transfer under the magnetic field is obtained. The large-scale temperature structure is show in the channel whole region.

2. Numerical method for direct numerical simulations

Our DNS code is hybrid spectral finite difference methods (Satake and Kunugi (2003) and Satake et al.(2003)). The number of grid points, the Reynolds number and grid resolutions summarized in Table 1. The periodic boundary conditions are applied to the streamwise (x) and the spanwise (z) directions. As for the wall normal direction (y), non-uniform mesh spacing specified by a hyperbolic tangent function is employed. The all velocity components imposed the non-slip condition at the wall. A uniform magnetic field $\boldsymbol{B}_0$ defines that the y-axis lies along the axis of the streamwise direction in Fig.1. The Neumann condition for the electrical potential is adopted at the wall: Insulation wall assumption. The Hartmann numbers ($Ha = \boldsymbol{B}_0\, 2\delta\, (\sigma/\rho\nu)^{1/2}$) based on the magnetic field $\boldsymbol{B}_0$, the kinematic viscosity ν, the electrical conductivity σ and the channel width 2δ are set to 32.5. The both wall are imposed to the constant temperature as thermal boundary conditions. The temperature difference is 1.0. The Prandtl number is set to be 0.06 as liquid metal.

Table I

Re_τ	Pr	Ha	Region	Grid number	Δx^+	Δy^+	Δz^+
1153	0.06	32.5	$5\pi\delta$x2δx$2\pi\delta$	1024x1024x768	16.8	0.16-4.2	8.9

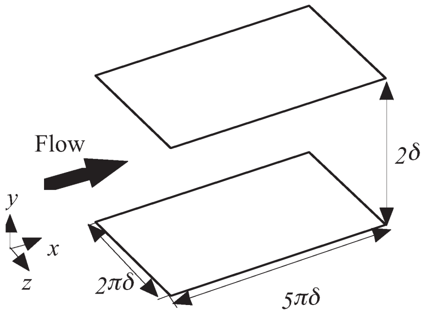

Figure 1 Computational domain.

3. Results

Mean temperature profiles normalized by friction temperature are shown in Fig. 2. The profiles are point symmetry at the channel center. Increasing with the strength of magnetic fields, the mean temperature profiles are tending to laminar profile. The 3D contour surface of temperature variance shows in Fig. 3. Large-scale temperature variance area appears in whole region. The area is not coincident to large-scale velocity structure. This reason is why both of low Prandtl effect and temperature boundary condition.

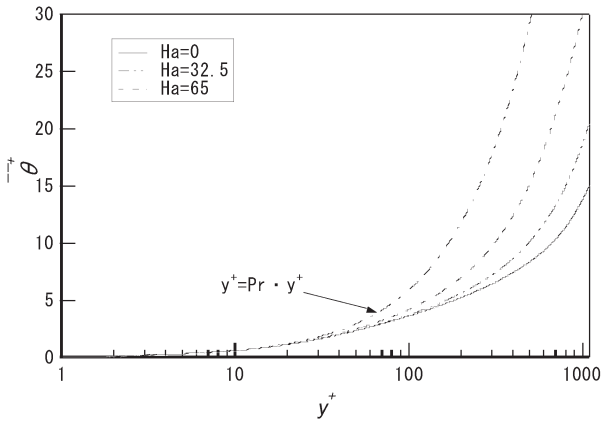

Figure 2 Mean temperature profiles

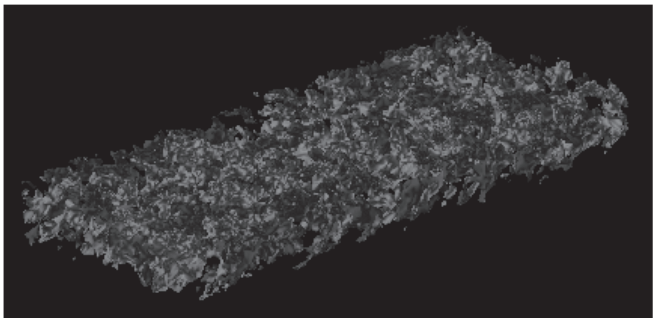

Figure 3 Temperature variance: Red, $\theta^+>3.0$, Blue, $\theta^+<-3.0$